



THE OHIO STATE UNIVERSITY

Managing Soil Health for Carbon Sequestration and Water Conservation

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SOIL ?



http://soilquality.org/indicators/soil_structure.htm
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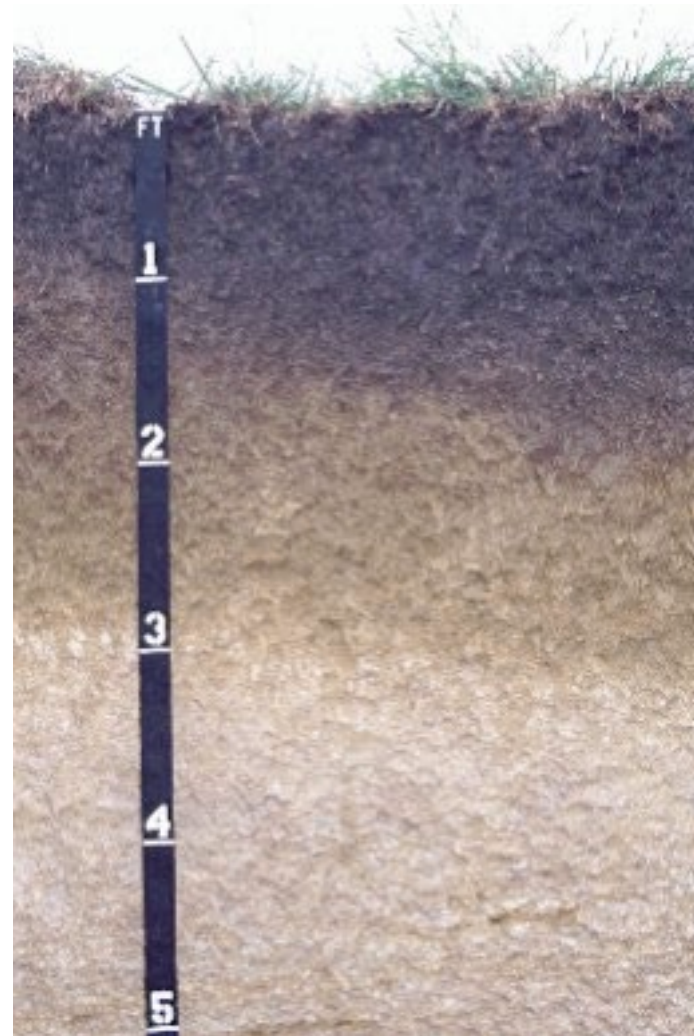
SOIL: THE ESSENCE OF LIFE

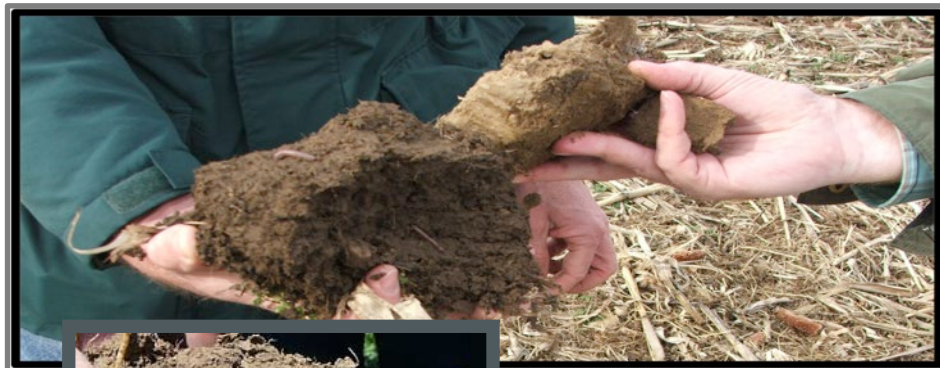
“Hello there folks. Do you know who or what I am? I am the geo-membrane of the Earth. I am your protective filter, your buffer, your mediator of energy, water, and biogeochemical compounds. I am your sustainer of productive life, your ultimate sources of elements, and the habitat for most biota. I am the foundation that supports you, the cradle of your myths, and the dust from which you will return. I am a soil”.



THE SOIL RESOURCE

1. Soil is the largest reservoir of C, plant nutrients, fresh water and biodiversity
2. The interaction between soil and other env. factors is the basis of all life





THE SOIL-LIFE NEXUS

Essentially all life
depends upon the soil
– There can be no life
without soil and no
soil without life; they
have evolved together
(Charles
E.Kellogg,USDA)

Rhizosphere is the only place
in the universe where the
death is resurrected into life.

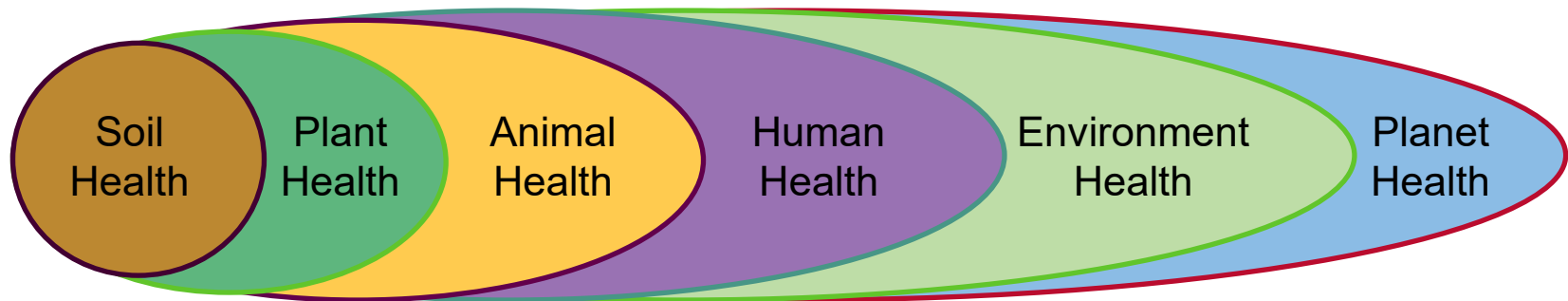


THE WAY FOOD IS PRODUCED AND CONSUMED

- **Affects the health of soil, plants, animals, people, ecosystems and the planet itself: the One Health Concept.**



SOIL, HUMAN, PLANET HEALTH NEXUS



(Lal 2020)

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe ." John Muir(1838-1914)



DIET AND HUMAN HEALTH

“When diet is wrong,
medicine is of no use.

When diet is correct,
medicine is of no need.”

Ayurveda



FOOD IS MEDICINE

**“Good food is a good
medicine that can prevent,
reverse, and even cure
disease.”**

Hyman (2019)

Good food is produced on a healthy soil

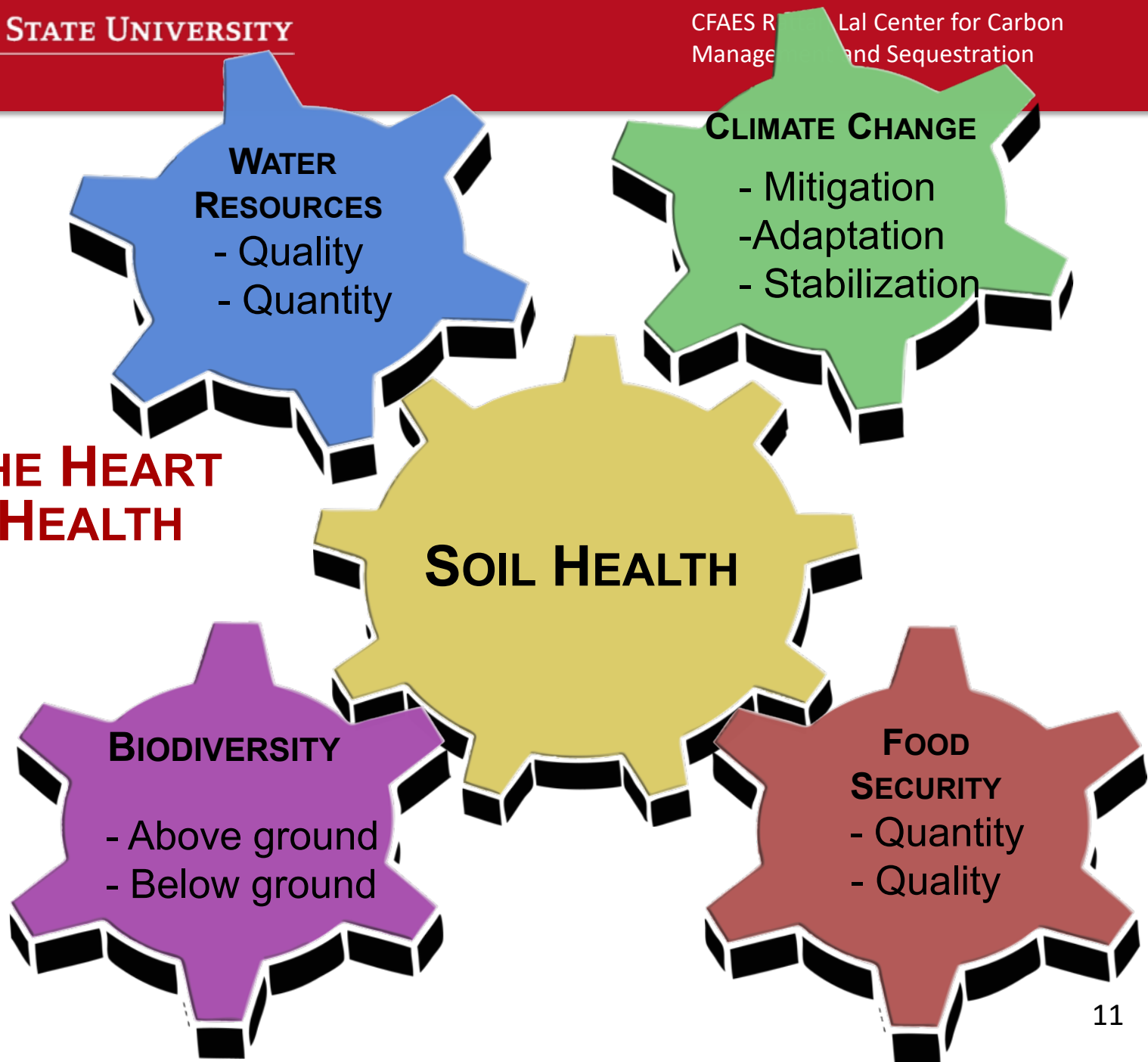


SOIL HEALTH

Soil's capacity to sustain multiple ecosystems services for human wellbeing and nature conservancy through coupled cycling with other elements.



**SOM IS THE HEART
OF SOIL HEALTH**

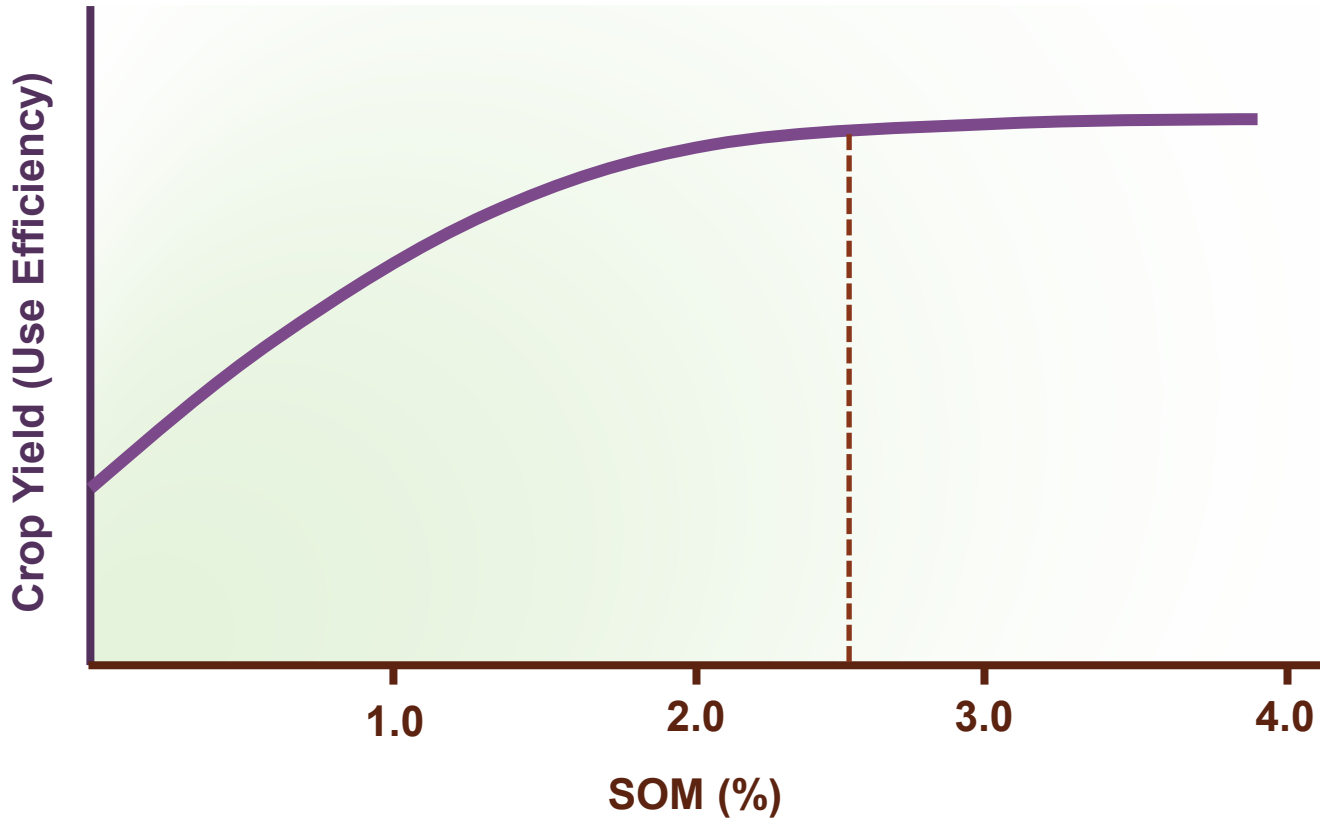




THRESHOLD LEVEL OF SOIL ORGANIC MATTER IN 0-30CM LAYER

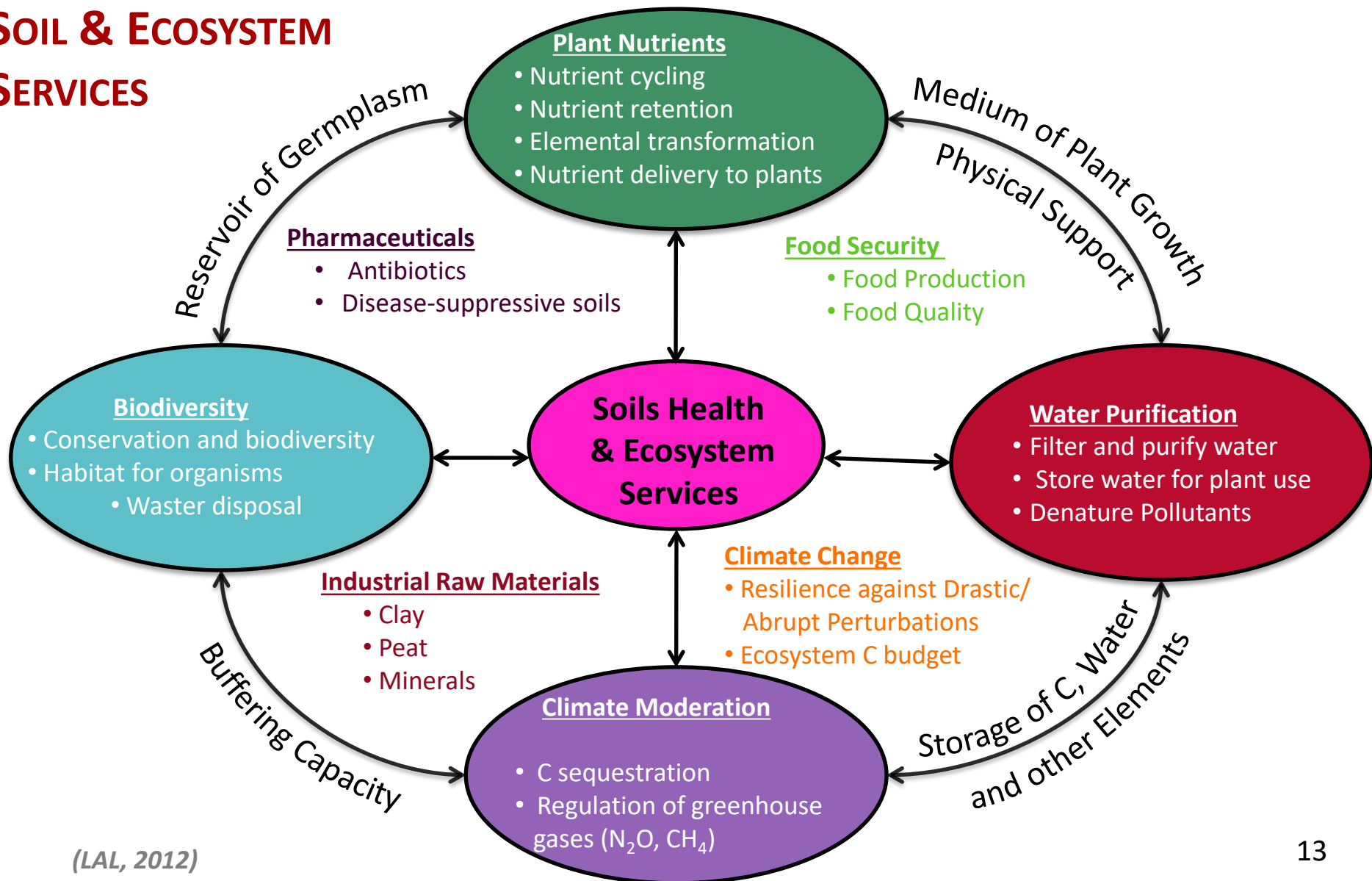
SOM : 2.5 - 3.5%

SOC : 1.5 - 2.0%





SOIL & ECOSYSTEM SERVICES



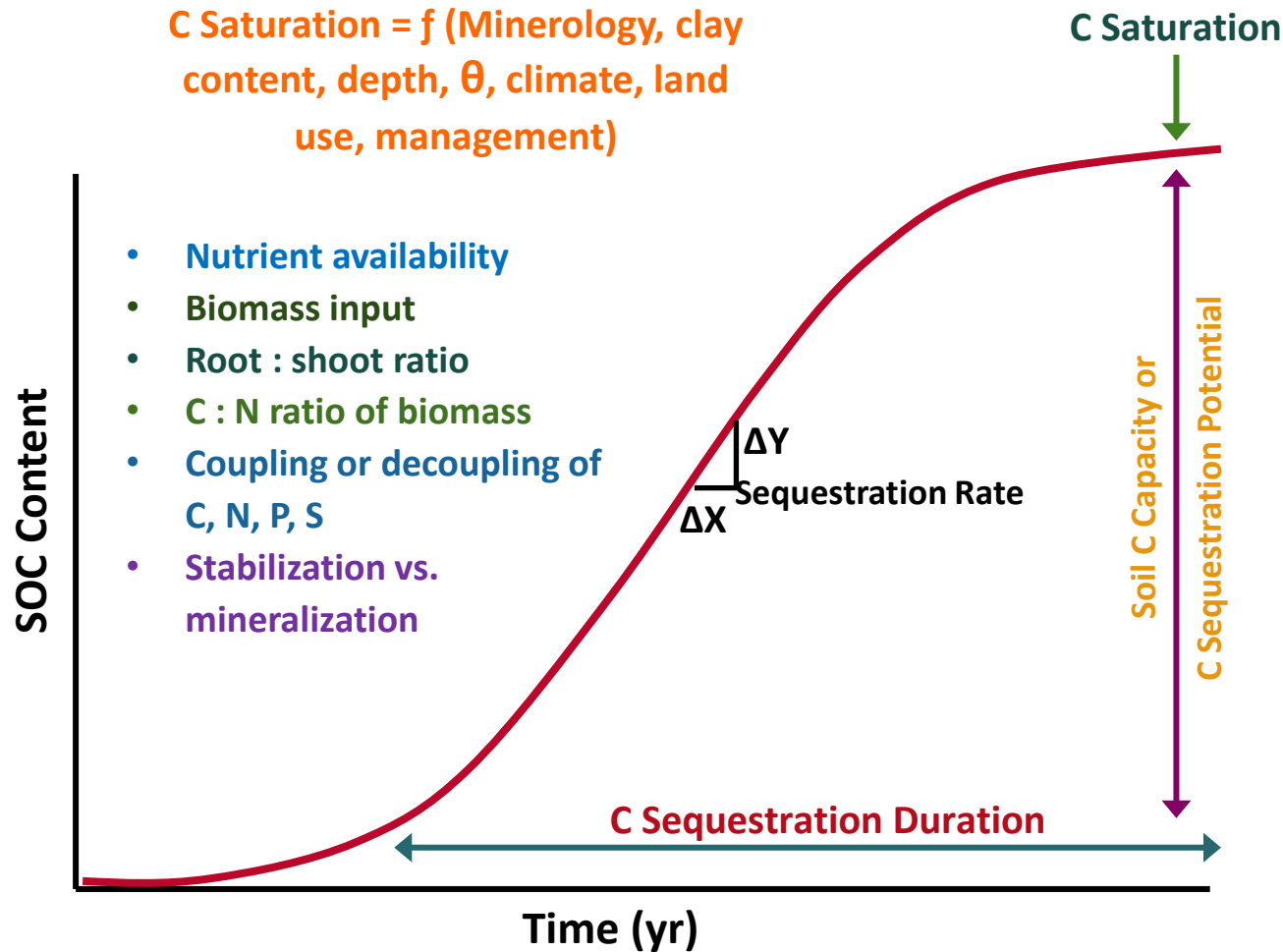


Carbon Sequestration

- **Transfer of atmospheric CO₂ into a long-lived pool so that it is not immediately re-emitted into the atmosphere.**
- **Sequestration can be oceanic, geologic, chemical, and terrestrial.**
- **Terrestrial Sequestration can be in soil, trees in all land uses (mine land, turfs)**

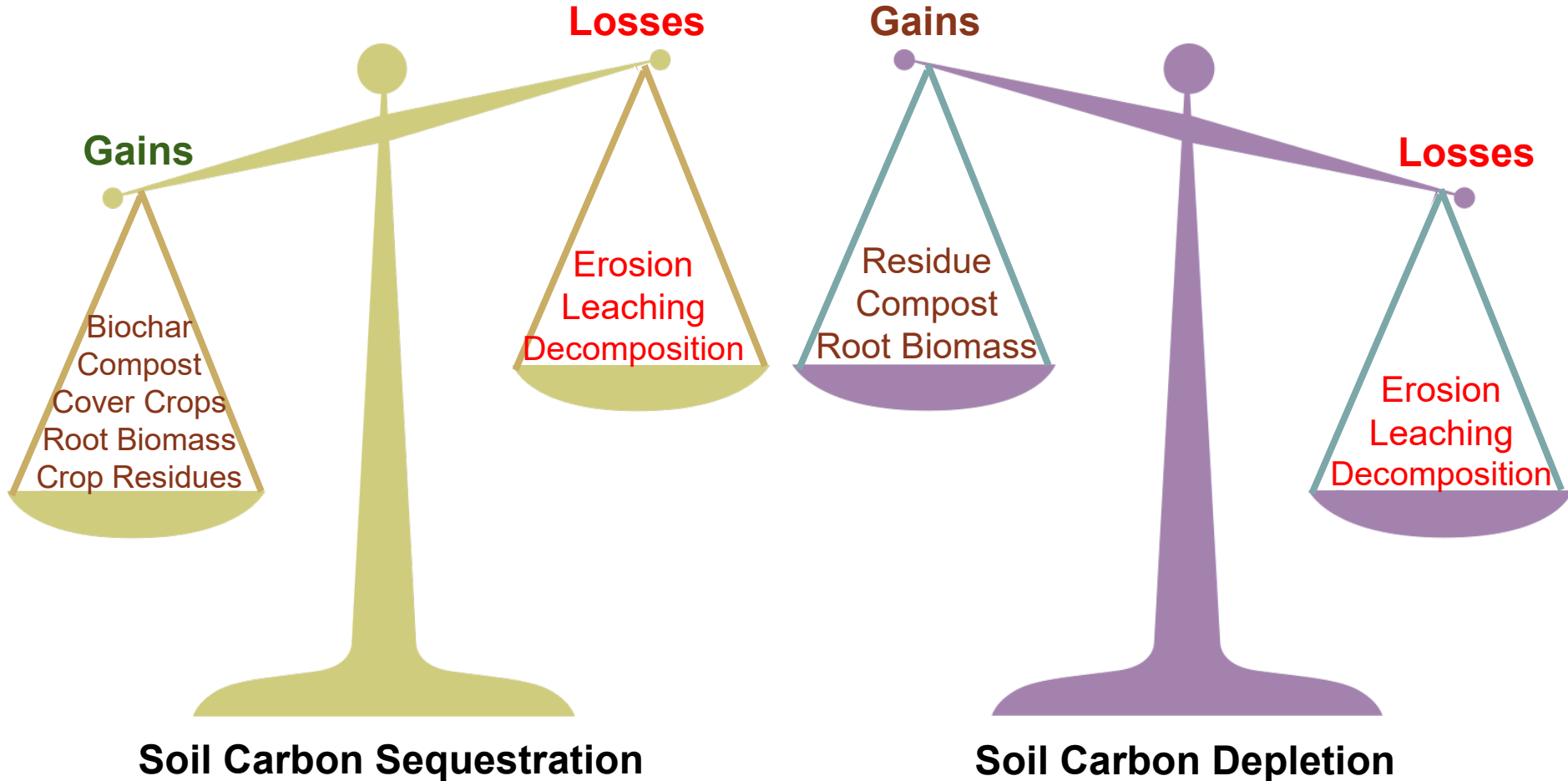


The Soil Carbon Sequestration Process by Plants





CREATING POSITIVE C BUDGET





A NO-TILL SEEDER



<https://www.no-tillfarmer.com>

**A heavy enough machinery to cut through the
residues and a powerful tractor to pull it.**



Direct Seeding in Crop Residue Mulch





Corn



(Successful Farming)



Soybeans



(American Society of Agronomy)



CLIMATE-RESILIENT SOIL: DROUGHT OF 2012



Corn with no residue.



Corn with 100% residue



CARBON-BASED FERTILIZATION

C **NPK**

rather than

NPK



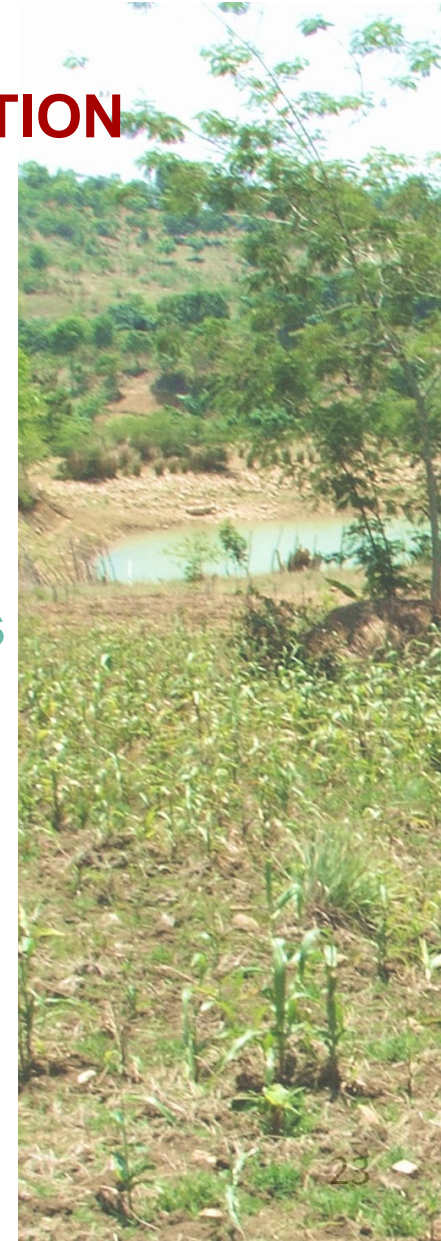


SOIL FARMING BY ECO- INTENSIFICATION

The strategy is to produce more food:

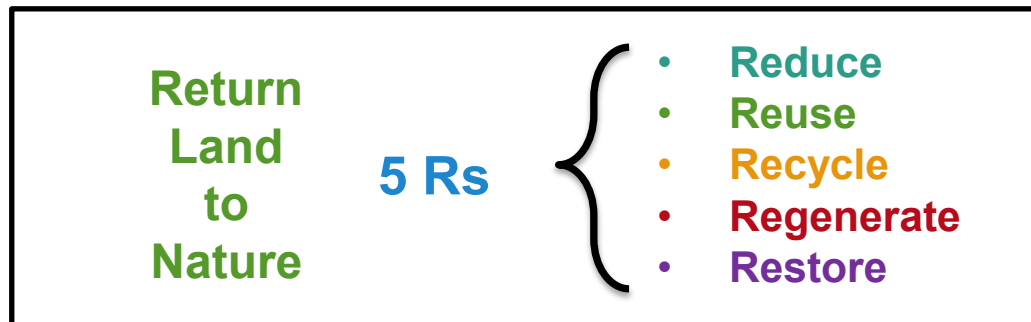
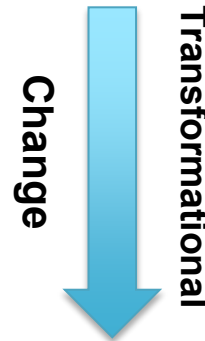
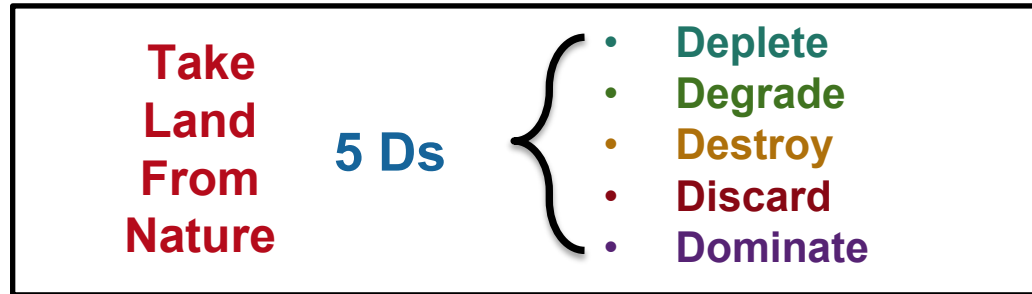
So that **Land**
is set aside
for **Nature**

- from **less land**,
- per **drop of water**,
- per **unit input of fertilizers and pesticides**,
- per **unit of energy**, and
- per **unit of C emission**.





TRANSFORMATIVE STRATEGIES



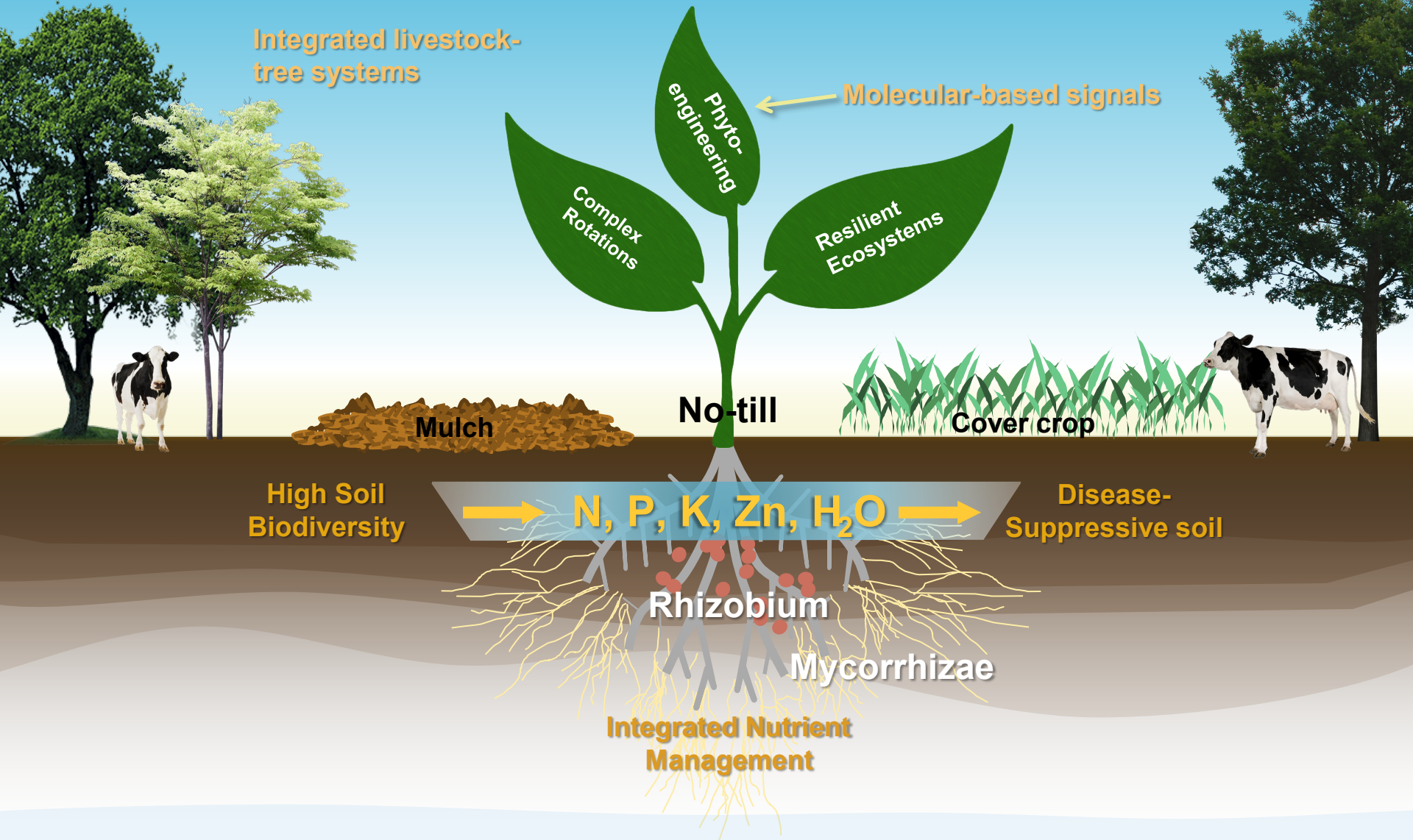


REGENERATIVE AGRICULTURE

Inspired by **eco-innovation**, powered by **non-carbon energy**, driven by a **circular economy** and **green infrastructure**, and supported by the **re-carbonization of the terrestrial biosphere** as the bedrock of **sustainable development**.

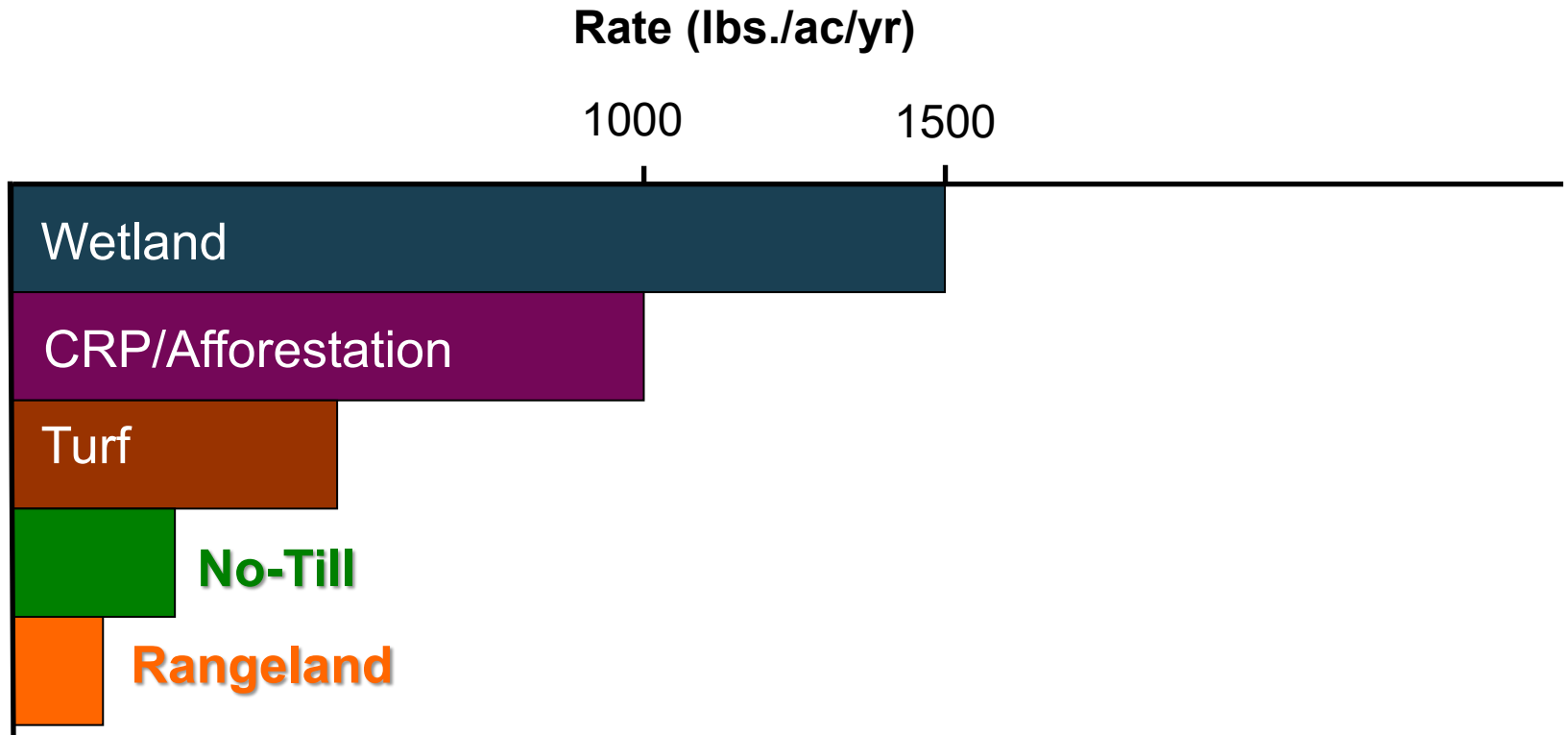


MANAGING SOIL HEALTH AND SOM





RATE OF CARBON SEQUESTRATION





Turfgrass Land Area

Ohio = 673,300 ha

USA = 59 million homeowners with lawns

~ 16.3 million ha of household lawns



Reclaimed Mined Soils

Ohio = 0.04 Mha

USA = 1.3 Mha

Constraints to Soil C SEQ in RMS:

1. Soil compaction
2. Topsoil thickness



CARBON SEQUESTRATION POTENTIAL OF SOILS OF THE U.S. (LAL ET AL., 2003)

Land Use	Area	Soil C Sequestration Potential (10 ⁶ ton/y)	
		Range	Mean
Cropland	156.9	45 – 98	72
Grazing Land	336.0	13 – 70	42
Forest Land	236.4	25 – 102	63
Land Conversion	70	21 – 77	49
Soil Restoration	217.2	25 – 60	42
Other Land Use	51.5	15 – 25	20
Total	916.3	144 – 432	288

Sequestration in Forest Biomass: 142 MMT **Total Land C Sink = 430 MMT/Y**

U.S. Emissions in 2022: 1730 MMT C **(one-fourth can be offset in soil and trees)**



TECHNICAL POTENTIAL OF C SEQUESTRATION

I. Soils 1.45 – 3.44 Pg C/yr (2.45 Pg C/yr)

Lal (2018)

II. Terrestrial Biosphere by 2100

- Soils 178 Pg
- Vegetation 155 Pg

Total 333 Pg (157 ppm CO₂)

Lal et al. (2018)



CROP YIELD INCREASE WITH INCREASE IN SOC BY 1 MgC/ha

Crop	Yield Increase (lbs./ac.ton C)
Maize	100 - 300
Soybeans	20 - 50
Wheat	20 - 70
Rice	10 - 50
Sorghum	80 - 140
Millet	30 - 70
Beans	30 - 60

- **Av. increase in crop yield of 40-100 lbs./ac.ton C**



Water Use in Agriculture

- **Food Crops Evaporate = 7,100 km³/yr. (7.1 x 10¹⁵L/yr.)**
- **Irrigation Water Use = 3,150 km³/yr.(3.15 x 10¹⁵ L/yr.)**

Water shortage is expected to worsen by 2030 in: Western Asia, Arabian Peninsula, northern and southern Africa, northeastern Australia, southwestern North America, and central South America



WATER PRODUCTIVITY IS THE KEY FACTOR

Increasing water productivity (more crop per drop) is the key strategy.

Soil being the best reservoir to store green water, restoring soil health is essential to increasing WP and mitigating drought.



ALLEVIATING DROUGHT BY C FARMING

- **Mulch farming/CA saves irrigation,**
- **DSI with CA mitigates drought,**
- **Solar irrigation syst. are viable,**
- **Increasing SOC increases AWC,
and**
- **Increasing AWC improves NUE and
mitigates/adapts to ACC**



FLOODS IN RIO GRADE: TWO SIDES OF THE SAME COIN



<https://scroll.in/article/918797/more-than-40-of-india-is-reeling-under-drought-but-the-centre-may-not-even-acknowledge-it>

<https://www.indiatoday.in/india/story/over-2-100-dead-in-monsoon-rains-floods-across-india-1607709-2019-10-09>



Saving of Fertilizer by Restoring SOM

At current fertilizer price, each 1% of
SOM provides \$750/acre of nutrients

Jim Hoorman (Ohio Extension Assistant Professor)



SOM ,SAVING N, & INCREASING CROP YIELD

- Each additional percent of OM in soil would save 31lb of N/ac.
- At \$0.67/lb. of N, It saves \$ 21/ac
- Increasing 1t C in soil may increase yield of corn by 100 -300 lbs/ac ,soybean by 20-50 lbs/ac, and wheat 20-70 lbs/ac.



FARMING CARBON

Growing soil carbon as a farm commodity that can create another income stream for farmers and land managers.



SOCIETAL VALUE OF SOIL ORGANIC CARBON

2010 Prices:

Inherent value: \$130/ton C (Nickel
per lb) = \$35/ton CO₂

- 2024 Prices: \$50 /ton CO₂



Carbon Farming in Ohio

Average Farm Size = 171 Acre

Area per Farm = 69.2 ha

C Sequestration per Farm = 34.6 ton

= 127 C credits/yr.

Income per Farm = \$6340/yr.



Carbon Farming in Ohio

Farmland in Ohio = 6.4 M ha

Rate of C Seq. = 0.5 Mg/ha

Total C Sequestration = 3.2 M Mt C

Total C Credits in Ohio = 11.7 M credits

Total Income in Ohio = \$500 M/yr. @
\$50/credit



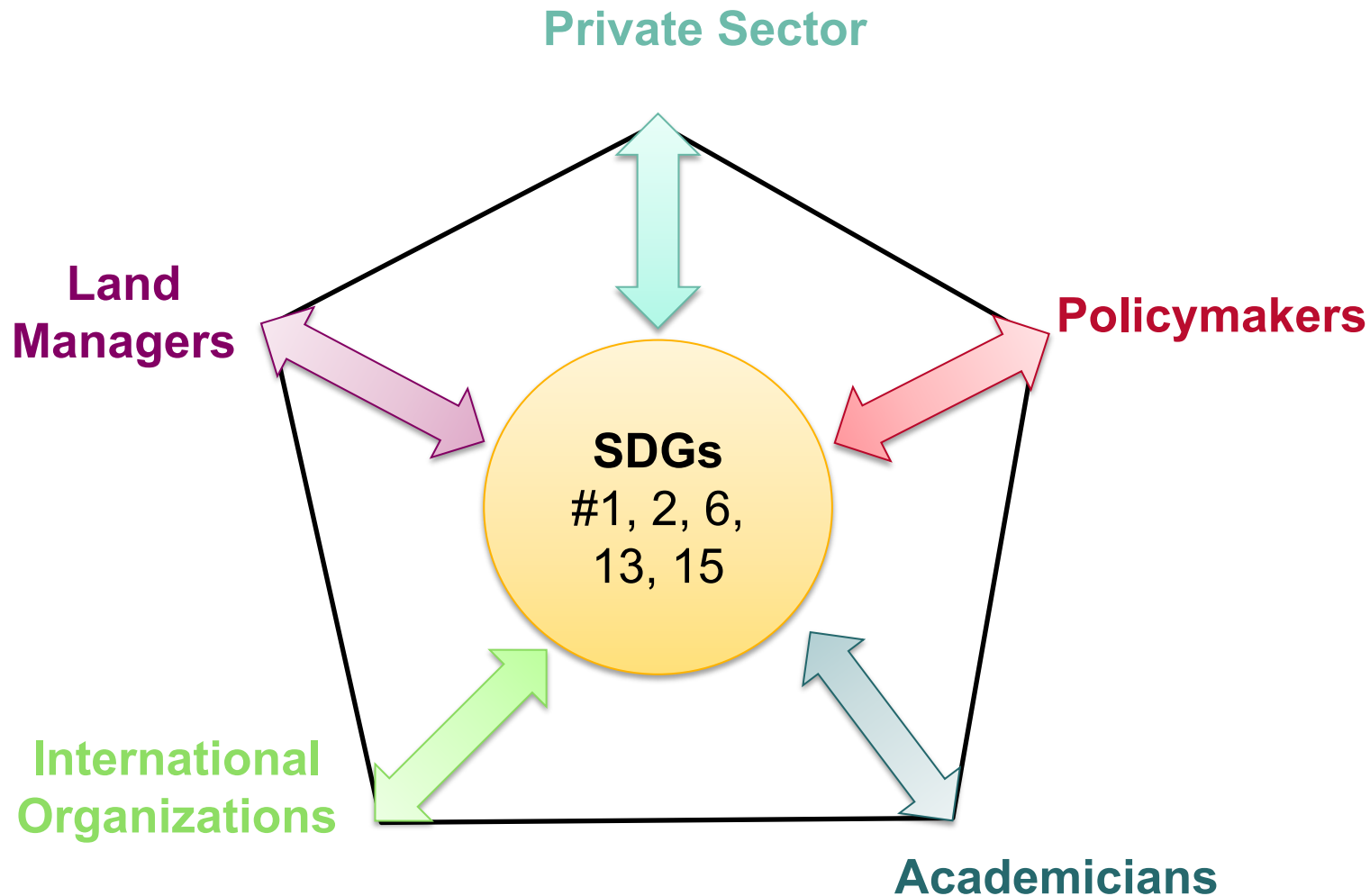
RIGHTS-OF-SOIL

Just as Universal Rights of Humans, rights of animals, there must also be rights of soil and rights of nature.

As the essence of all life, soils have rights to be protected, restored, thrive and managed judiciously.

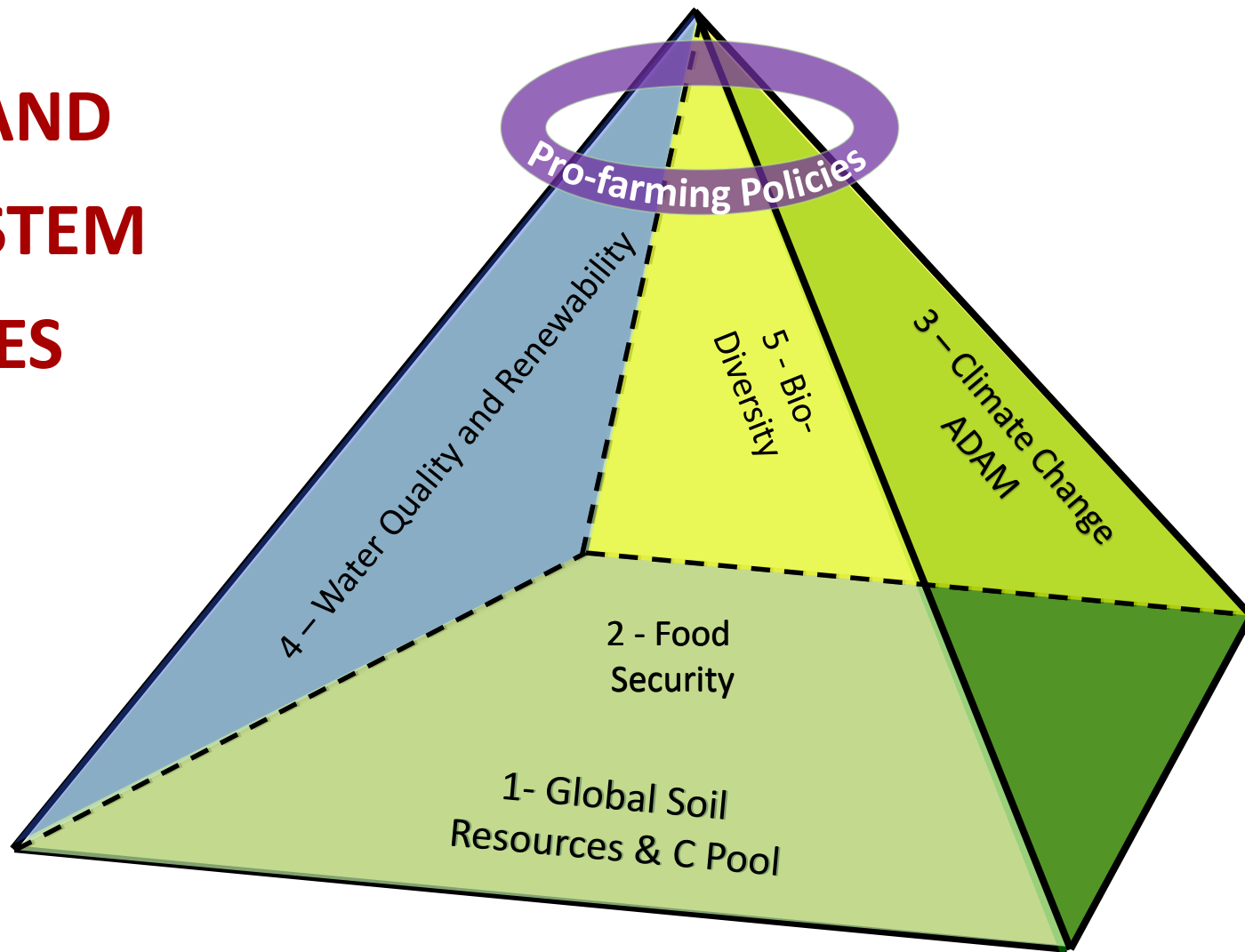
Prime agricultural land, and ecologically sensitive ecoregions must be protected

COOPERATION WITH THE PRIVATE SECTOR



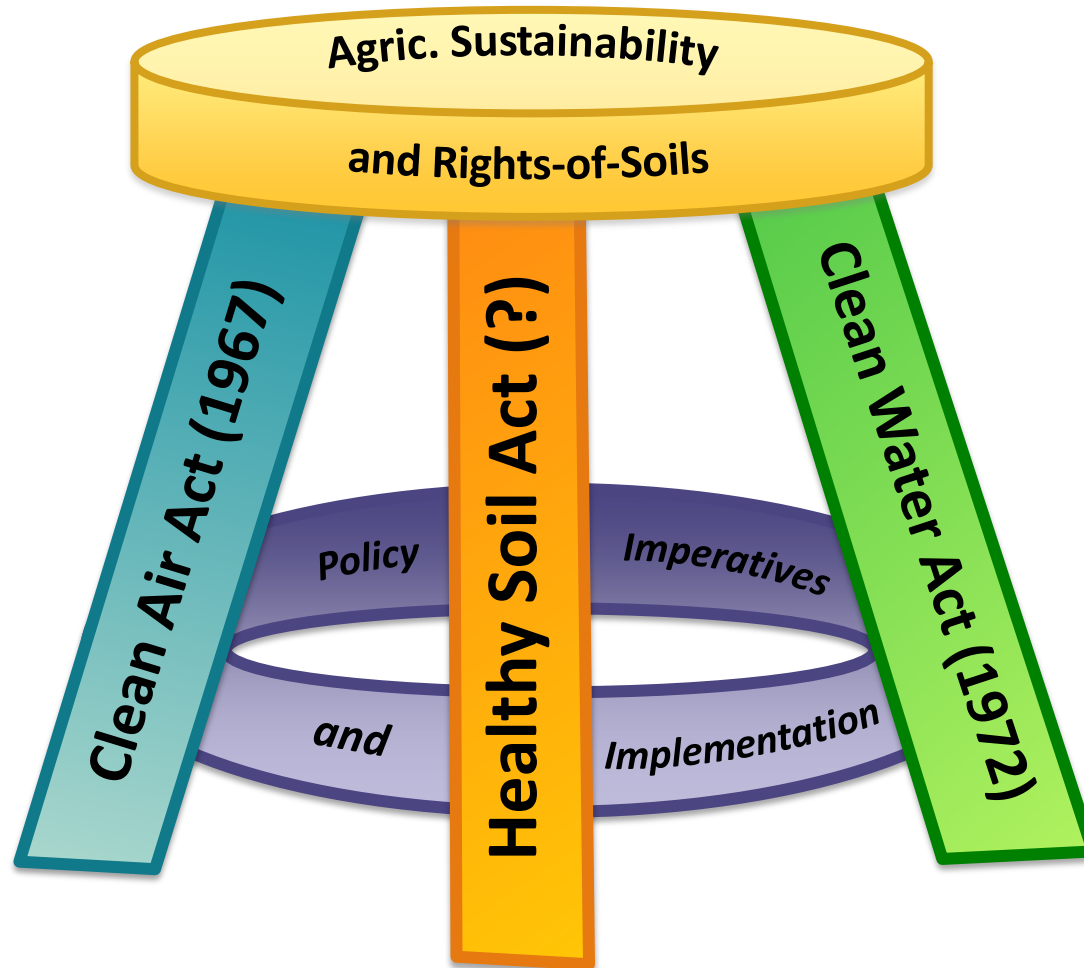


SOILS AND ECOSYSTEM SERVICES





SOIL HEALTH ACT (FARM BILL)





Soil is Also a Victim of Any War



War Effects on Soil Health

- Whether missiles are fired because of hatred or fear, both people and soil suffer.
- War degraded soil and polluted/contaminated water and air take decadal/centennial time scale to purify and restore
- There are 3 stakeholders in any war: two nations or communities and the soil/land on which they fight. The soil/land/nature is the silent victim that no one talks or cares about.
- No body has any authority to destroy the precious , finite and the fragile soil resource on which depend the wellbeing of present and future generations.



World Peace and Soil Health

Global peace is also a scientific issue. Advancing science of soil health, nutrition-sensitive agriculture, food processing and biofortification etc. are critical and high priority scientific issues with strong impact on world peace and stability **by building bridges across nations.**



SOIL & CIVILIZATION

Soil stewardship and care must be embedded in every fruit and vegetable eaten, in each grain ground into the bread consumed, in every cup of water used, in every breath of air inhaled, and in every scenic landscape cherished.

Eroding soils and denuded lands, depleting soil organic matter and declining soil fertility, recurring drought and intensifying heat waves, low crop yields and perpetual hunger, and marginal living and desperateness are as real threats to global peace and security as are ICBMs and WMDs ,and thus the soil and natural resources must be protected, restored , used judiciously and never ever taken for granted.

Famines and wars are man-made tragedies We must make famine and mass-starvation politically intolerable, morally toxic, ethically unthinkable, and humanely unacceptable.



THE MANTRA

**“Healthy Soil = Healthy
Diet = Healthy People =
Healthy Ecosystems =
Healthy Planetary
Processes = World Peace”**